

The Orientation of Galaxies in Galaxy Clusters.

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ABSTRACT

We present an analysis of the spatial orientations of galaxies in the 247 optically selected rich Abell clusters, having in the considered area at least 100 members. We investigated the relation between angles giving information about galaxy angular momenta and the number of members in each structure. The position angles of the galaxy major axes, as well as two angles describing the spatial orientation of galaxy plane were tested for isotropy, by applying three different statistical tests. It is found that the values of statistics increase with the amount of galaxies' members, which is equivalent to the existence of the relation between anisotropy and number of galaxies in cluster. The search for connection between the galaxies alignments and Bautz - Morgan morphological types of examined clusters gave weak dependence. The statistically marginal relation between velocity dispersion and cluster richness was observed. In addition, it was found that the velocity dispersion decreases with Bautz - Morgan type at almost 3σ level. These results show the dependence of alignments with respect to clusters' richness, which can be regarded as environmental effect.

Subject headings: galaxies: clusters: general

1. Introduction

One of the most important aim of modern extragalactic astronomy and cosmology is to solve the problem of structure formation. There are many theories used to develop scenarios of structure formations (Peebles 1969; Zeldovich 1970; Sunyaew & Zeldovich 1972; Doroshkevich 1973; Shandarin 1974; Dekel 1985; Wesson 1982; Silk 1983; Bower 2005). In the commonly accepted Λ CDM model, the Universe seems to be spatially flat, as well as homogeneous and isotropic at appropriate scale. However, the dimension of this scale is changing with the growth of our knowledge of the Universe. In this model the structure were formed from the primordial adiabatic, nearly scale invariant Gaussian random fluctuations (Silk 1968; Peebles & Yu 1970; Sunyaew & Zeldovich 1970). This picture is in agreement with both the numerous numerical simulations (Springel 2005; van de Weygaert & Bond 2008a,b) and the observations. The crucial goal is to determine the discrimination among different models of galaxy formation. An investigation of the orientation of galaxies in clusters is regarded as a standard test of theories of galaxy and large scale structure formation. Thus, theories of the galaxy formation make predictions regarding to the angular momenta of galaxies (Peebles 1969; Doroshkevich 1973; Shandarin 1974; Silk 1983; Catelan & Theuns 1996; Li 1998; Lee 2000, 2001, 2002; Navarro 2004; Trujillo et al. 2006). This parameter is known for certain for only very few galaxies in structures. Therefore, instead of the angular momenta, the orientation of galaxies pertinent to each cluster is investigated. In order to acquire this, either the distribution of galaxy position angles only or the orientation of galaxy planes were examined.

An interesting problem emerges in the case of dependence on the alignment to the mass of the structure. Godlowski et al. (2005) suggested that alignment of galaxies in cluster should increase with the number of objects in particular cluster. There is no clear empirical evidence that galaxy groups and clusters rotate (see e.g. Hwang & Lee (2007))

. Thus, it can be accepted that the total angular momentum of galaxy structure is mainly connected with the galaxies' spins. Moreover, stronger alignment suggests greater total angular momentum of galactic groups or clusters.

The study of galaxy orientation, which substitutes the investigation of the galaxy's spin distribution, yields different results. Nevertheless, it is clear that in isolated Abell clusters of galaxies only the dominant brightest cluster members exhibit the sign of alignment (Flin & Olowin 1991; Trevese et al. 1992; Kim 2001; Panko et al. 2009). However, very rich galaxy clusters, such as A754 (Godłowski 1998), A14 (Baier, Godłowski & MacGillivray 2003) or A1656 (Djorgovski 1983; Wu 1997, 1998) have shown non-random distribution of galaxies.

Godłowski et al. (2005) suggestion that alignment should increase with richness of the cluster was already confirmed by Aryal (2007) (based on the series of paper (Aryal 2004, 2005, 2006)). They analyzed totally 32 clusters of different richness and BM types, founding that alignment is changing with the richness as well as BM type of the clusters. However, both Godłowski et al. (2005) and Aryal (2007) analysis was qualitative only. Our aim is to test this hypothesis both qualitatively and quantitatively. Therefore we decided to examine if alignment of galaxies in clusters depends on the number of their constitutive members and the BM types using statistical tests.

Plionis et al. (2003) suggested that galaxy alignment in cluster depends on the velocity dispersion of member galaxies. In order to verify this finding we also analyzed correlation between alignment and velocity dispersion.

The present paper is organized in standard manner. Section 2 describes our optical data, section 3 presents the statistical method used in our analysis. Section 4 is devoted to our results and their discussion, while section 5 contains conclusions which ends the paper.

2. Observational data

Our paper is based on the analysis of structures taken from PF catalogue (Panko 2006). The structures were extracted from the Muenster Red Sky Survey (MRSS hereafter) (MRSS 2003). MRSS is optical large scale survey covering an area of 5000 square degrees in the southern hemisphere. After scanning 217 ESO plates, it gives the information about 5,5 million galaxies. PF catalogue, like MRSS, is statistically complete till magnitude value $m = 18^m.3$ and it contains structures having at least ten members in a magnitude range between m_3 and $m_3 + 3$, where m_3 is the magnitude of the third brightest galaxy located in the considered structure region. The catalogue contains hints about each structure. Structures were found involving the Voronoi tessellation technique, which was in detail described in our previous paper (Panko et al. 2009). The galaxy membership was ascribed to cluster during construction of the PF Catalogue. We are disposing the information which galaxy belongs to a given structure. The data for each galaxy member were taken from the MRSS. These includes: the equatorial coordinates of galaxies(α , δ), the diameters of major and minor axes of the galaxy image (a and b respectively) and the position angle of the major axis, p . In the present paper we selected rich clusters having at least 100 members and being identified with one of ACO clusters (Abell et al. 1989), which gave us the Bautz-Morgan morphological types (BM types). There are 239 such objects in the PF catalogue. Moreover, 9 objects can be identified with two ACO clusters. We have also taken them into account, which increased our sample to 248 objects. However, we excluded from our analysis A3822, which potentially has substructures (Biviano et al. 1997, 2002). Therefore, our sample has 247 objects.

Data dealing to velocity dispersion of galaxies were taken from the literature. We found such clues for 97 clusters (Alonso et al. 1999; De Propris et al. 2002; Fadda et al. 1996; Mazure et al. 1996; Muriel et al. 2002; Struble & Rood 1999).

We had two samples of data. In the first sample all galaxies lying in the region regarded as cluster were taken into account. In the second sample only galaxies brighter than $m_3 + 3$ were considered. The second sample should contain purely cluster members.

3. The method of investigation

Historically, two main methods for studying galaxy orientation were proposed. In the first one (Hawley & Peebles 1975) the analysis of the distribution of the observed position angle of the galactic image major axis was carried out. In this approach the face-on and nearly face-on galaxies were excluded from the analysis. The second approach allowed us to use the face-on galaxies as well. This method, based on the de-projection of the galaxy images, was originally proposed by Oepik (1970), applied by Jaaniste & Saar (1978) and significantly modified by Flin & Godłowski (1986); Godłowski (1993, 1994). In this method not only the distribution of galactic position angles p is being analyzed, but also another important parameter - the galaxy's inclination with respect to the observer's line of sight i is being considered. Two possible orientations of the galaxy plane were determined, which gave two possible directions perpendicular to the galaxy plane. It is expected that one of these normals corresponds to the direction of galactic rotation axis. Any study of galactic orientation based on the projection of galaxies on the celestial sphere gives a four-fold ambiguity in the solution for angular momentum. By the reason of none information connected with the direction of the galaxy spin our analysis is reduced to only two solutions.

The inclination angle was calculated according to the formula: $\cos^2 i = (q^2 - q_0^2)/(1 - q_0^2)$, where observed axial ratio $q = b/a$ and q_0 is "true" axial ratio. Formula mentioned above is valid for oblate spheroids (Holmberg 1946). Because of the lack of information about morphological types of galaxies in MRSS catalogue we used standard value $q_0 = 0.2$.

For each galaxy, two angles are determined: δ_D - the angle between the normal to the galaxy plane and the main plane of the coordinate system, and η - the angle between the projection of this normal onto the main plane and the direction towards the zero initial meridian. Using the equatorial coordinate system, the following relations hold between angles (α, δ, p) and (δ_D, η)

$$\sin \delta_D = -\cos i \sin \delta \pm \sin i \cos r \cos \delta, \quad (1)$$

$$\sin \eta = (\cos \delta_D)^{-1} [-\cos i \cos \delta \sin \alpha + \sin i (\mp \cos r \sin \delta \sin \alpha \pm \sin r \cos \alpha)], \quad (2)$$

where $r = p - \pi/2$.

As a result of the reduction of our analysis into two solutions it is necessary to consider the sign of the expression: $S = -\cos i \cos \delta \mp \sin i \cos r \sin \delta$ and for $S \geq 0$ reverse sign of δ_D , respectively. ¹ Separately we repeat all calculations using supergalactic coordinate system (Hawley & Peebles 1975).

In order to detect non-random effects in the distribution of the investigated angles: δ_D , η and p we carried out three different statistical tests. At first, we checked whether the distributions of the investigated angles (δ_D , η and p) in each individual cluster were isotropic. In analyzing of the distribution of the two angles δ_D , η it is possible to use galaxies of any orientation - including face-on galaxies. Therefore for analysis of the distribution of the angles δ_D , and η all galaxies' members were considered. It is very difficult to determine in a precise manner the position angles for galaxies seen face-on and nearly face-on. Moreover, these angles can yield reliable information with respect to galaxy planes only for galaxies seen edge-on. Thus, in the study of the position angles distribution,

¹See (Flin & Godłowski 1986) for detailed explanation, however please note that there is a printed error in formulae for S .

face-on and nearly face-on galaxies were excluded from the analysis. In this case galaxy's members with axial ratio $b/a \leq 0.75$ were taken into consideration only.

In all applied statistical tests the entire range of the investigated θ angle (where for θ one can put $\delta_D + \pi/2$, η or p) is divided into n bins. We use $n = 36$ bins of equal width. We repeated our analyses using also different values of bin's width; no significant difference appeared among results. The χ^2 test yields the critical value of 49.8 for 35 degrees of freedom (at the significance level $\alpha = 0.05$).

If deviation from isotropy is a slowly varying function of the θ angle one can use the Fourier test (Hawley & Peebles 1975):

$$N_k = N_{0,k}(1 + \Delta_{11} \cos 2\theta_k + \Delta_{21} \sin 2\theta_k) \quad (3)$$

where N_k - the number of galaxies within k-th angular bin and as $N_{0,k}$ - the expected number of galaxies per bin.

If theoretical probability function p_k is uniform (i.e $N_{0,k}$ are equal, as it is in the cases of the η and p angles) or symmetric with respect to the value $\theta = \pi/2$ (i.e. with respect to value $\delta_D = 0$ in the case of δ_D angle) we obtain the following expressions for the Δ_{i1} coefficients:

$$\Delta_{11} = \frac{\sum_{k=1}^n (N_k - N_{0,k}) \cos 2\theta_k}{\sum_{k=1}^n N_{0,k} \cos^2 2\theta_k}, \quad \Delta_{21} = \frac{\sum_{k=1}^n (N_k - N_{0,k}) \sin 2\theta_k}{\sum_{k=1}^n N_{0,k} \sin^2 2\theta_k} \quad (4)$$

with the standard deviation given by the expressions:

$$\sigma(\Delta_{11}) = \left(\sum_{k=1}^n N_{0,k} \cos^2 2\theta_k \right)^{-1/2} \approx \left(\frac{2}{nN_0} \right)^{1/2}, \quad \sigma(\Delta_{21}) = \left(\sum_{k=1}^n N_{0,k} \sin^2 2\theta_k \right)^{-1/2} \approx \left(\frac{2}{nN_0} \right)^{1/2}. \quad (5)$$

The probability that the amplitude

$$\Delta_1 = (\Delta_{11}^2 + \Delta_{21}^2)^{1/2} \quad (6)$$

is greater than a certain chosen value is given by the formula:

$$P(> \Delta_1) = \exp \left(-\frac{1}{2} \left(\frac{\Delta_{11}^2}{\sigma(\Delta_{11}^2)} + \frac{\Delta_{21}^2}{\sigma(\Delta_{21}^2)} \right) \right) \approx \exp \left(-\frac{n}{4} N_0 \Delta_1^2 \right) \quad (7)$$

with standard deviation of the amplitude:

$$\sigma(\Delta_1) \approx \left(\frac{2}{nN_0} \right)^{1/2} \quad (8)$$

In cases of testing η and p angles we can put $=$ instead of \approx .

This test was originally introduced by Hawley & Peebles (1975) and substantially modified by Godłowski (1993, 1994). In the paper Godłowski (1994) the case with higher Fourier modes taken into account was discussed:

$$N_k = N_{0,k}(1 + \Delta_{11} \cos 2\theta_k + \Delta_{21} \sin 2\theta_k + \Delta_{12} \cos 4\theta_k + \Delta_{22} \sin 4\theta_k + \dots). \quad (9)$$

Amplitude Δ it is now the function for all four Δ_{ij} coefficients. Generally, when we take into consideration both Fourier modes 2θ and 4θ , the formulas are complicated and this was discussed in details in Godłowski (1994)².

From the sign of Δ_{11} coefficient one can deduce the direction of departure from isotropy. If $\Delta_{11} < 0$, then the excess of the galaxies with θ angle near 90° is observed. It indicates for example that in the case of the position angles ($\theta \equiv p$) $\Delta_{11} < 0$ means that the excess of galaxies with position angles near 90° (parallel to main plane of the coordinate system) is observed. If $\Delta_{11} > 0$ then the excess of objects with position angles perpendicular to the

²However, please note that there is a printed error in Godłowski (1994). eq. 18 should have form: $P(\Delta) = (1 + J/2) \exp(-J/2)$

main plane of the coordinate system is observed. Therefore, for $\Delta_{11} > 0$ the rotation axis projections tends to be parallel to the main plane.

In the case of δ_D angle the situation is more complicated. However, if we restrict our analysis only to the case of the absolute value of δ_D angle, then we could neglect Δ_{21} and Δ_{22} coefficients, because they are equal to zero (see also (Flin & Godłowski 1986; Aryal 2004, 2005, 2006, 2007)). In that case Δ_1 is reduced to $|\Delta_{11}|$, while Δ , now denoted as Δ_c , is the function of coefficients Δ_{11} and Δ_{12} only. However, please note that Δ_{11} and Δ_{12} are not independent of each other (Godłowski 1994).

We also performed the investigation of the linear regression given by $y = aN + b$ counted for various parameters. These were carried out for each investigated angle separately. We studied the linear regression between: the values of different statistics χ^2 , $\Delta_1/\sigma(\Delta_1)$, $\Delta/\sigma(\Delta)$ and the number of analyzed galaxies in each particular cluster. In the case of δ_D , the values of statistics : χ^2 , $|\Delta_{11}/\sigma(\Delta_{11})|$, $\Delta_c/\sigma(\Delta_c)$ and the number of analyzed galaxies in each particular cluster were considered.

We assumed that the theoretical, uniform, random distribution contains the same number of objects as the observed one. Our null hypothesis H_0 is that the distribution is a random one. In such a case the statistics $t = a/\sigma(a)$ has Student's distribution with $u - 2$ degrees of freedom, where u is the number of analyzed clusters. It means that we tested H_0 hypothesis that $t = 0$ against H_1 hypothesis that $t > 0$. In order to reject the H_0 hypothesis, the value of the observed statistics t should be greater than t_{cr} . Our sample has 247 clusters. For this sample, at the significance level $\alpha = 0.05$, the value $t_{cr} = 1.651$, while for the sample of 97 clusters with known values of velocity dispersion, the value $t_{cr} = 1.660$.

Similarly, using linear regression we looked for possible relations between the values of applied statistics: χ^2 , $\Delta_1/\sigma(\Delta_1)$ and $\Delta/\sigma(\Delta)$ (or χ^2 , $|\Delta_{11}/\sigma(\Delta_{11})|$ and $\Delta_c/\sigma(\Delta_c)$ in the case of δ_D angle) and the BM type of each cluster. The linear regression between values

of above mentioned statistics and velocity dispersion of galaxies inside cluster was also examined.

The linear regression analyses were performed independently for the sample containing all galaxies in the cluster area (sample A), as well as for the sample restricted to galaxies brighter than $m_3 + 3$ (sample B).

4. Results and discussion

We analyzed the distribution of three angles connected with the orientations of galaxies in the sample of 247 rich Abell clusters. The the distribution of the position angels, δ_D angles and η angles for two previously investigated clusters A2721 and A2554 (Aryal 2007) were presented in the Fig.1 Our results are very similar to that obtained by Aryal (2007) i.e. isotropic distribution for position angles and spin vectors of galaxies tend to lie in the Local Supercluster plane. Also our result for η angles are similar to (Aryal 2007). However our interpretation seems to be a little bit different - projection of the spin vectors of galaxies tends to be oriented in direction $L = -45^\circ$, not perpendicular with respect to the Virgo Cluster centre.

The dependencies on the values of the applied statistics used in our study and the cluster richness for three investigated angles: p , δ_D , and η were shown on Fig.2-4 respectively. We studied the linear regression $y = aN + b$ between the values of each statistics and three parameters, namely: the number of galaxies in cluster N , cluster morphological type BM and galaxy velocity dispersion $\sigma(V)$. The above calculations were performed separately for samples A and B , as well as for each tested for isotropy angle p , δ_D and η . The values of the regression coefficients a and b , with its errors for each investigated case were collected in Table 1 (equatorial coordinate sysem) and Table 2 (supergalactic

coordinate sysem).

Fig.2 present the dependence on the applied three statistics χ^2 , $\Delta_1/\sigma(\Delta_1)$ and $\Delta/\sigma(\Delta)$ for position angle and cluster richness N . Fig.3 and Fig.4 present the same relations for δ_D and η angles respectively. For the position angle p only the χ^2 test and only when we use the equatorial coordinates as a reference system statistics $t = a/\sigma(a) = 1.67$ is greater than $t_{cr} = 1.65$ at the significance level $\alpha = 0.05$. In equatorial cordinates, in the case of the δ_D angle all applied statistics showed $t > t_{cr}$. We obtained $t = 3.11$ in the case of $y = \chi^2$ test, $t = 2.35$ for $y = |\Delta_{11}/\sigma(\Delta_{11})|$ and $t = 3.26$ for $y = \Delta_c/\sigma(\Delta_c)$. The distribution of the η angle is even more anisotropic, because we obtained $t = 6.0$ in the case of $y = \chi^2$ test and $t = 3.83$ and $t = 5.50$ in two remaining tests respectively. In supergalactic coordinates the picture is similar but the efect is much stronger than in the case of the equatorial coordinates. For restricted sample to galaxies brighter than $m_3 + 3$, anisotropy is even stronger when for the sample including all galaxies in the cluster area, as well as for the position angles even in the case of the Fourier test statistics $t = a/\sigma(a)$ reached critical value $t_{cr} = 1.65$. This results clearly confirm Godlowski et al. (2005) suggestion that the alignment of galaxies in clusters increased with the number of members in clusters.

We have found only weak correlation and only in the case of using supergalactic coordinates, between values of the analyzed statistics and BM type of the clusters. We found a weak correlation between the values of the analyzed statistics and velocity dispersion $\sigma(V)$ for p angle and δ_D angle. However, only for position angle and only in the case of Fourier test the value of the statistics $t = a/\sigma(a)$ reached the critical value $t_{cr} = 1.66$. Moreover, for supergalactic coordinates, we obtain negative dependence for angle δ_D in the case of the Fourier test.

We also investigated the relation between the number of galaxies belonging to the cluster and BM type, the velocity dispersion of galaxies belonging to the cluster and

cluster BM type, as well as between cluster richness and velocity dispersion (Fig5, Tab.3). In Fig.5a we present the relation between the cluster richness and BM type. The values of statistics are smaller than t_{cr} . It means, that we do not observe the relation between richness and BM type. Fig.5b shows the relation between velocity dispersion $\sigma(V)$ and BM type. In this case the value of statistics $t = 2.99$, which is greater than t_{cr} , therefore we conclude that velocity dispersion decreases with BM type. This effect is almost at 3σ level. In Fig. 5c the dependence on the cluster richness and the velocity dispersion is presented. The value $t = a/\sigma(a) = 1.31$ in the case of p angle and $t = 1.18$, when considering the orientation of galaxy planes.

5. Conclusions

We analyzed the alignment of galaxies belonging to 247 Abell clusters containing at least 100 members. Using statistical tests we confirmed suggestion of Godlowski et al. (2005) that non randomness of galaxy orientation in clusters increases significantly with the cluster richness. Such confirmation follows from the analyses of all three investigated angles δ_D , η and p . These angles are connected with the orientation of galaxies and therefore with the distribution of galaxy angular momenta. The effect increases if we restricted the cluster membership to galaxies brighter than $m_3 + 3$, which suggest that this effect is really connected with clusters.

The observed dependency on the alignment of galaxies in clusters and richness of the cluster leads to the conclusion that angular momentum of the cluster increases with the mass of the structure. Usually this dependence is presented as empirical relation $J \sim M^{5/3}$ (Wesson 1979, 1983; Carrasco 1982; Brosche 1986). The aim of this relation has been discussed for a long time. One of the first explanation was proposed by Muradyan (1975) in terms of the Ambarzumian's superdense cosmogony, while Mackrossan (1987) involved

thermodynamical consideration for its explanation. Wesson (1983) argued that this is a consequence of self similarity of Newtonian problem applied to rotating gravitationally bound systems. The relation was used for pointing out its possible role in the unification of the gravitation and particle physics (Wesson 1981). Catelan & Theuns (1996) joined the relation $J \sim M^{5/3}$ with the model of galaxy formation. They explained it as a consequence of the tidal torque model. Sistero (1983) incorporated the rotational velocity of the Universe. A similar approach was presented by Carrasco (1982) who explained this relation as a consequence of mechanical equilibrium between the gravitational and rotational energy, while Li (1998) proposed more general relation for $J(M)$ and explained it as a result of the influence of the global rotation of the Universe on the structure formation. Our finding is in agreement with prediction of the Li model (Li 1998; Godlowski et al. 2005).

In our opinion the observed relation between the richness of galaxy cluster and the alignment is due to tidal torque, as suggested by Catelan & Theuns (1996). Moreover, the analysis of the linear tidal torque theory is pointing in the same direction (Noh & Lee 2006a,b). They noticed the connection of the alignment with the considered scale of structure.

We found a strong correlation between BM type and the velocity dispersion. The velocity dispersion decreases with BM type. We found only weak correlation between the alignment and BM type, claimed by Aryal and Saurer (Aryal 2004, 2005, 2006, 2007). Our sample of clusters is an order of magnitude greater than that one analyzed by them. Moreover this weak correlation is found only in the case of using supergalactic coordinate system as the reference system. The correlation between the alignment and velocity dispersion of galaxies belonging to clusters was found by Plionis et al. (2003). In our data this effect is statistically insignificant (it is at $1,5\sigma$ level). Moreover, it is noted only in the case of A sample, not in B sample restricted to galaxies brighter than $m_3 + 3$. In

PF Catalogue the position angles of brighter galaxies, which is the brightest member, the second, third and tenth brightest galaxy are distributed randomly (Panko et al. 2009), while the present analysis of all galaxies in cluster shows an anisotropic distribution. If brighter galaxies are located more centrally, and dimmer ones are located outside rich clusters somewhere in the sheets and filaments in which clusters are embedded, then the discussed possible effects are environmental ones. When the distribution of dimmer galaxies in cluster follows that one for brighter galaxies, the appearance of the alignment in richer region can also be regarded as the environmental effect. Therefore, we concluded that the richness - alignment relation is of environmental origin. The performed analyses have shown that there are several clear as well as somewhat obscure relations between such parameters as: the alignment of galaxies in clusters, the velocity dispersion, cluster BM type and density of galaxies in clusters. Further investigation in this direction should reveals the connection among these parameters, which should sheds light to formation and evolution of clusters.

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A. The list of investigated clusters

A list of the investigated clusters is given in Table 4. The particular columns give the clues about: *PFNumber*- the name of the each structure in Panko-Flin Catalogue, α and δ of the cluster center, N_0 - the number of galaxies in the field of structure, N_1 - the number of galaxies with $b/a \leq 0.75$, *Name*- structure identification with (Abell et al. 1989). The last three columns gives the galaxies alignments (with respect to supergalactic coordinate system). We presented the results for supergalactic position angle P , polar angle δ_D and azimuthal angle η . Bottom indexes 0 and ? denote isotropic distribution and situation that we can not decided if it's anisotropic or isotropic distribution, respectively. For P and δ_D angles \parallel index denotes that spin vector of galaxies tends to be parralel to supergalactic plane, while \perp index denotes that spin vector of galaxies is perpendicular to the supergalactic plane. For the η angle \parallel index denotes that projection of the spin vector to the supergalactic plane tends to be parralel to the direction connecting Galaxies with the Virgo Cluster (Supercluster center). The \searrow index denotes that in all cases we observed anisotropic distribution but no special direction of deviation from isotropy (especialy parallel or perpendicular) was found.

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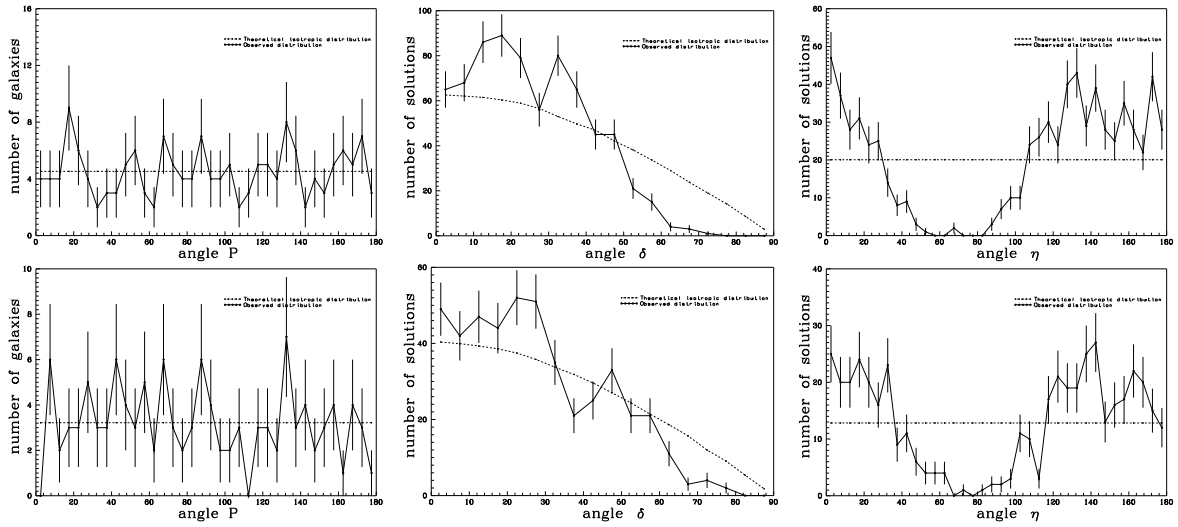


Fig. 1.— The distribution of the position angles - left panel, δ_D angles - middle panel and η angles - right panel, for clusters: A2721 - upper panel and - A2554 bottom panel (supergalactic coordinate system). We presented theoretical isotropic distributions (dashed lines) and observed distributions. The error bar were presented as well.

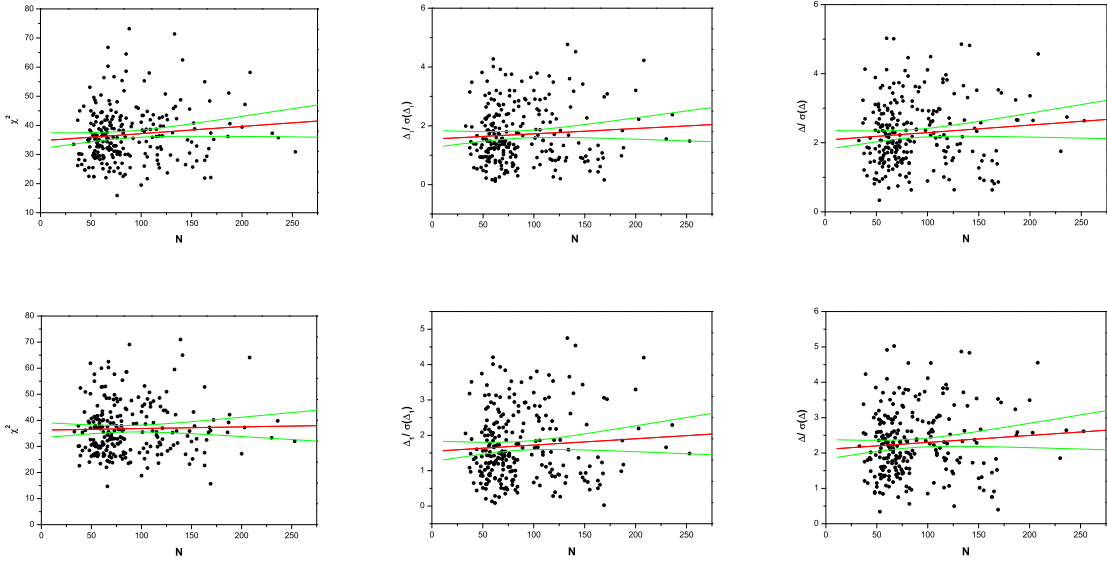


Fig. 2.— The relation between the number of galaxies in the cluster N and the value of analyzed statistics (χ^2 - left panel, $\Delta_1/\sigma(\Delta_1)$ - middle panel, $\Delta/\sigma(\Delta)$ - right panel) for the position angles p . Upper panel - equatorial coordinates, bottom panel - supergalactic coordinates. The bounds error, at confidence level 95%, were presented as well.

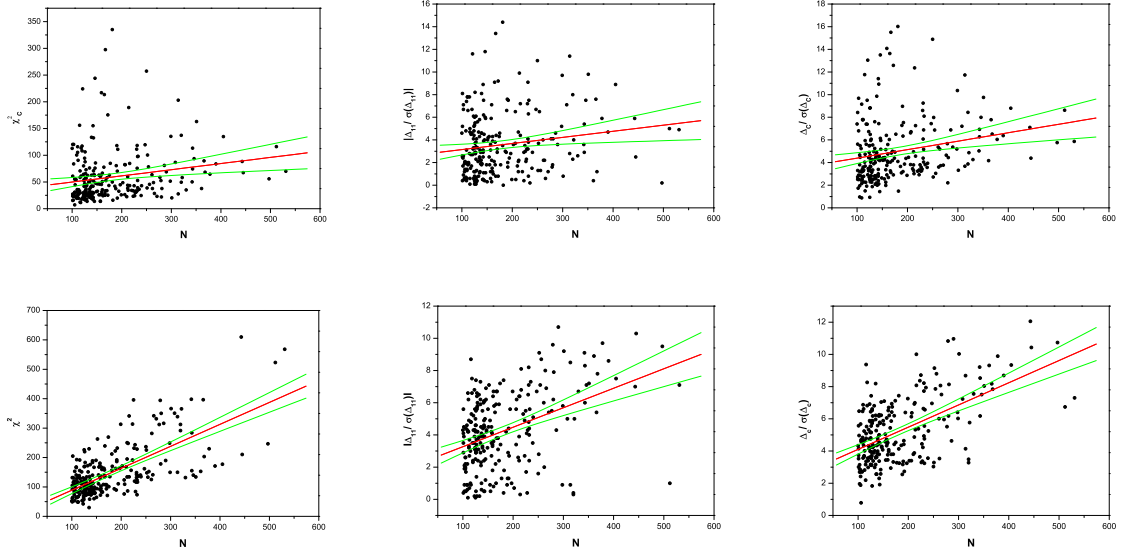


Fig. 3.— The same as in fig.2 but for δ_D angles. Upper panel - equatorial coordinates, bottom panel - supergalactic coordinates.

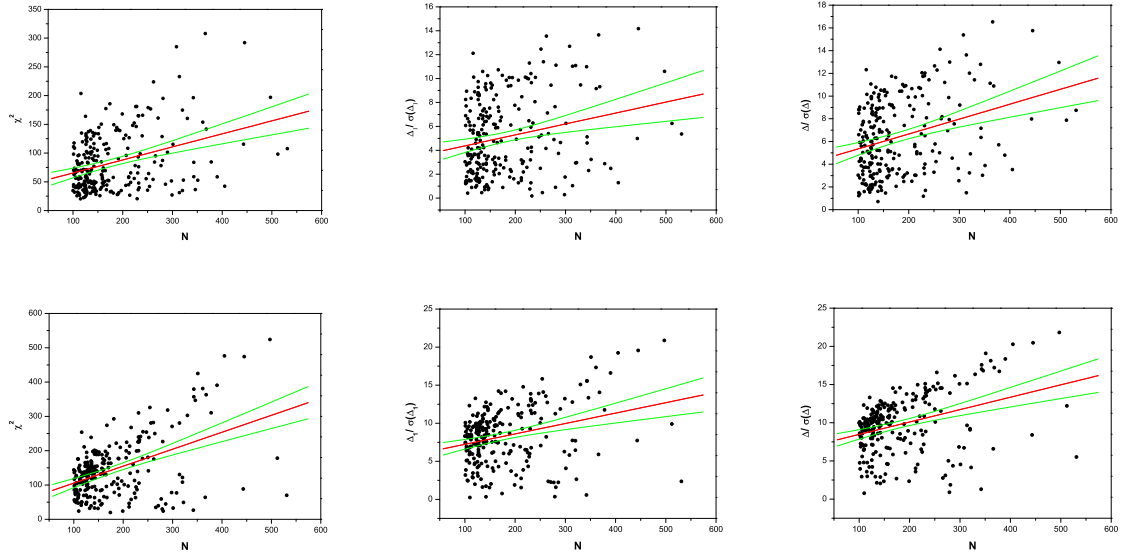


Fig. 4.— The same as in fig.2 but for η angles. Upper panel - equatorial coordinates, bottom panel - supergalactic coordinates.

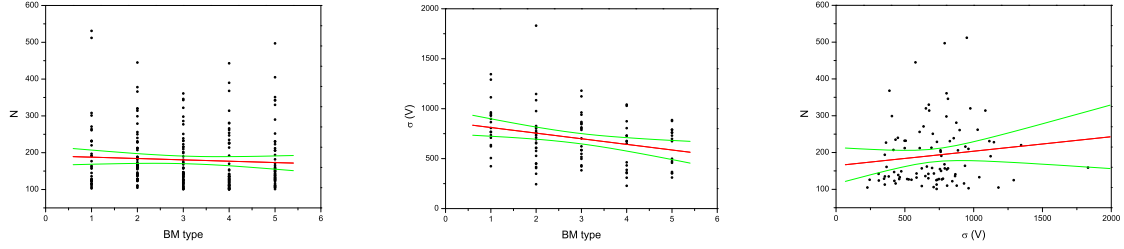


Fig. 5.— The dependence between the number of galaxies in each cluster N and BM type - left panel, the velocity dispersion $\sigma(V)$ and BM type - middle panel, the number of galaxies in each cluster N and velocity dispersion $\sigma(V)$ - right panel. The bounds error, at confidence level 95%, were shown. BM type is coded as follows: BMI as 1, $BMI - II$ as 2, $BMII$ as 3, $BMII - III$ as 4 and $BMIII$ as 5.

Table 1: The results of the linear regression analysis - equatorial coordinates.

χ^2					$\Delta_1/\sigma(\Delta_1)$				$\Delta/\sigma(\Delta)$			
sample	a	$\sigma(a)$	b	$\sigma(b)$	a	$\sigma(a)$	b	$\sigma(b)$	a	$\sigma(a)$	b	$\sigma(b)$
N												
A												
P	0.025	0.015	34.7	1.4	0.0018	0.0015	1.55	0.15	0.0022	0.0015	2.08	0.14
δ	0.115	0.037	38.4	7.4	0.0054	0.0021	2.60	0.41	0.0075	0.0021	3.65	0.41
η	0.228	0.038	42.7	7.4	0.0092	0.0024	3.46	0.49	0.0132	0.0024	4.03	0.49
B												
P	0.036	0.021	33.8	1.6	0.0033	0.0020	1.39	0.15	0.0032	0.0019	1.98	0.15
δ	0.178	0.047	25.5	7.4	0.0096	0.0026	1.78	0.42	0.0128	0.0028	2.58	0.43
η	0.324	0.042	26.5	6.7	0.0174	0.0032	2.06	0.47	0.0210	0.0030	2.69	0.47
BM												
A												
P	0.085	0.044	36.6	1.5	0.0137	0.0450	2.22	0.15	0.0129	0.0409	1.42	0.13
δ	−3.98	4.20	57.0	7.4	0.0518	0.2518	3.10	0.42	−.1572	0.2604	4.66	0.44
η	1.958	4.979	80.6	8.4	0.1110	0.3150	4.93	0.53	0.1122	0.3240	6.23	0.55
B												
P	0.272	0.459	35.5	1.6	0.0868	0.0434	1.36	1.14	0.0339	0.0427	2.10	0.14
δ	−5.26	4.72	67.3	8.0	0.0070	0.2642	3.57	0.44	−.2328	0.2674	5.35	0.45
η	3.074	4.320	68.6	7.2	0.2572	0.2940	4.16	0.49	0.2294	0.3012	5.38	0.51
$\sigma(V)$												
A												
P	0.001	0.003	35.4	2.5	0.0005	0.0003	1.13	0.22	0.0005	0.0003	1.72	0.23
δ	0.033	0.024	33.4	9.1	0.0019	0.0018	2.00	0.68	0.0014	0.0015	3.66	0.58
η	−.012	0.041	100.	16.	−.0006	0.0026	6.19	0.98	−.0007	0.0026	7.53	0.99
B												
P	0.001	0.003	34.9	2.4	0.0003	0.0003	1.18	0.23	0.0002	0.0003	1.87	0.23
δ	0.012	0.018	31.8	6.9	0.0007	0.0015	1.93	0.57	0.0006	0.0014	2.29	0.52
η	0.001	0.003	34.9	2.4	0.0003	0.0003	1.18	0.23	0.0002	0.0003	1.87	0.23

Table 2: The results of the linear regression analysis - supergalactic coordinates.

χ^2					$\Delta_1/\sigma(\Delta_1)$				$\Delta/\sigma(\Delta)$			
sample	a	$\sigma(a)$	b	$\sigma(b)$	a	$\sigma(a)$	b	$\sigma(b)$	a	$\sigma(a)$	b	$\sigma(b)$
N												
A												
P	0.006	0.016	36.2	1.5	0.0018	0.0015	1.55	0.15	0.0020	0.0015	2.10	0.14
δ	0.280	0.023	7.9	4.6	0.0121	0.0017	2.06	0.34	0.0138	0.0014	2.72	0.26
η	0.498	0.059	56.1	12.	0.0136	0.0028	5.87	0.56	0.0162	0.0028	6.85	0.55
B												
P	0.031	0.021	34.0	1.6	0.0035	0.0020	1.38	0.15	0.0033	0.0019	1.99	0.14
δ	0.308	0.026	4.5	4.0	0.0152	0.0020	1.48	0.32	0.0178	0.0016	2.02	0.25
η	0.586	0.064	36.4	11.	0.0228	0.0036	4.06	0.55	0.0250	0.0034	5.03	0.54
BM												
A												
P	0.049	0.048	36.6	1.6	0.0775	0.0472	1.46	0.15	0.0163	0.0448	2.22	0.15
δ	5.137	3.582	50.4	6.0	0.5380	0.2286	3.40	0.38	0.3240	0.1924	4.70	0.32
η	19.66	8.197	114.	14.	0.9366	0.3604	6.88	0.61	0.8536	0.3618	8.45	0.61
B												
P	0.259	0.463	35.5	1.6	0.0885	0.0435	1.36	1.15	0.0375	0.0420	2.10	0.14
δ	3.644	2.941	43.3	4.9	0.5432	0.2066	2.86	0.35	0.3382	0.1798	4.08	0.30
η	−10.0	6.816	138.	11.	−.4794	0.2922	8.36	0.49	−.5000	0.3006	9.27	0.51
$\sigma(V)$												
A												
P	0.001	0.004	34.6	2.7	0.0005	0.0003	1.09	0.23	0.0004	0.0003	1.74	0.23
δ	−.028	0.027	66.6	10.	−.0031	0.0018	5.25	0.69	−.0020	0.0014	5.81	0.54
η	−.012	0.070	158.	27.	−.0006	0.0030	8.95	1.13	0.0004	0.0030	10.2	1.14
B												
P	0.004	0.003	31.9	2.6	0.0003	0.0003	1.17	0.23	0.0002	0.0003	1.92	0.23
δ	−.020	0.022	52.4	8.4	−.0020	0.0016	4.54	0.62	−.0022	0.0014	5.06	0.51
η	−.012	0.070	158.	27.	−.0006	0.0030	8.95	1.13	0.0004	0.0030	10.2	1.14

Table 3: The results of the linear regression analysis. We presents the dependence between the number of galaxies in clusters N , Bautz-Morgan type BM and the dispersion of the velocities $\sigma(V)$ (fig.4). P - denotes case of position angle, while $F - G$ Flin-Godlowski method ($\delta+\eta$ angles), respectively.

sample	a	$\sigma(a)$	b	$\sigma(b)$
$\sigma(V)(BM)$	56.26	19.09	867.9	60.5
$N(BM)$				
sample A				
$F - G$	-3.66	3.94	191.5	13.3
P	-1.92	1.95	93.3	6.6
sample B				
$F - G$	-0.105	2.917	144.8	9.8
P	-0.100	0.707	71.2	4.8
$N(\sigma(V))$				
sample A				
$F - G$	0.039	0.033	164.2	24.9
P	0.021	0.016	79.9	12.1
sample B				
$F - G$	0.013	0.025	134.1	19.1
P	0.007	0.011	66.1	8.6

Table 4. The list of investigated clusters

PF Number	α [h]	δ [deg]	N_0	N_1	Name	P	δ_D	η
0003-4377	0.0332940	-43.764385	252	135	s1173			
0004-3061	0.0424033	-30.608407	125	69	s0001	0		
0004-2722	0.0496337	-27.211477	162	80	A2716	\searrow		
0009-3469	0.0918712	-34.681737	361	163	A2721	0		
0016-3529	0.1643087	-35.281307	235	124	s0012	0		
0017-6446	0.1783953	-64.454778	101	38	A2732	0		0
0020-6640	0.2000360	-66.392536	112	56	A2737	0	?	\perp
0020-4224	0.2046051	-42.236308	106	52	A2736	0		
0021-1727	0.2142782	-17.267194	116	33	s0015			
0022-1954	0.2286907	-19.534202	206	106	A0013	0		
0024-4251	0.2431575	-42.500865	112	54	A2745	0		
0024-2387	0.2475143	-23.860490	314	169	A0014			
0025-2612	0.2536075	-26.112302	128	73	A0015			
0027-3136	0.2734246	-31.358321	150	82	A2751	0		
0028-4990	0.2864895	-49.896367	161	76	A2753			
0029-3513	0.2910976	-35.125399	497	230	A2755	0		
0031-2046	0.3153715	-20.456570	102	53	s0026	0		
0031-4187	0.3180634	-41.863651	231	101	A2758	\searrow		
0034-2570	0.3429825	-25.697728	213	118	A0022	0		
0035-4930	0.3514239	-49.297151	168	73	A2764			
0040-4010	0.4030093	-40.091711	129	57	A2771	0		

Table 4—Continued

PF Number	α [h]	δ [deg]	N_0	N_1	Name	P	δ_D	η
0041-6581	0.4136137	-65.805361	139	61	A2770	\perp	\parallel	\perp
0042-3308	0.4259923	-33.076987	172	76	s0041	0	\parallel	\parallel
0042-3799	0.4273978	-37.982872	160	77	A2772	0	\parallel	\parallel
0043-6910	0.4301972	-69.092017	172	85	A2775	\perp	?	?
0045-5021	0.4503612	-50.207339	144	58	A2777	0	\parallel	\parallel
0047-2362	0.4761155	-23.614121	141	76	A0042	\parallel	\parallel	\parallel
0058-3907	0.5820089	-39.062564	118	67	s0061	\parallel	\parallel	?
0061-6439	0.6129856	-64.384850	101	56	A2796	0	?	?
0062-2845	0.6221154	-28.448334	143	66	A2798	0	\parallel	\parallel
0066-2896	0.6620048	-28.953170	256	108	A2798	?	\parallel	\parallel
0069-2869	0.6950245	-28.682962	445	186	A2804	0	\parallel	\parallel
0072-2610	0.7234165	-26.093608	194	89	A0088	\perp	\parallel	\parallel
0076-1816	0.7601967	-18.151027	135	55	A2816	0	\parallel	\parallel
0076-6353	0.7650574	-63.526130	299	155	A2819	0	\parallel	\perp
0078-5470	0.7843686	-54.699737	145	77	s0077	?	?	?
0082-2951	0.8211987	-29.507452	110	56	s0084	0	\parallel	\parallel
0084-5025	0.8476005	-50.246897	118	56	A2827	\parallel	\parallel	\parallel
0088-4758	0.8873193	-47.576920	113	68	A2836	0	?	\parallel
0089-2178	0.8925053	-21.776334	128	61	A0114	0	\parallel	\parallel
0092-2637	0.9213817	-26.368269	136	62	A0118	0	\parallel	\parallel
0095-3094	0.9586092	-30.931841	126	44	s0109	\perp	\parallel	\parallel

Table 4—Continued

PF Number	α [h]	δ [deg]	N_0	N_1	Name	P	δ_D	η
0097-6680	0.9762100	-66.790348	190	106	s0112	0	?	\perp
0098-3428	0.9839121	-34.279133	207	103	A2847	?	\parallel	\parallel
0104-2195	1.0481967	-21.940614	157	84	A0133	0	\parallel	\parallel
0105-3995	1.0520281	-39.940742	264	116	A2857	\parallel	\parallel	\parallel
0109-2457	1.0975451	-24.566583	136	78	A0141	\perp	\parallel	\parallel
0113-3674	1.1319391	-36.739609	116	48	A2871	0	\parallel	\parallel
0114-4031	1.1455260	-40.306519	164	80	A2874	0	\parallel	\parallel
0115-4600	1.1567254	-45.996573	261	125	A2877	?	\parallel	\parallel
0117-2480	1.1703771	-24.798778	139	76	A0155	0	\parallel	\parallel
0132-6468	1.3204981	-64.674528	111	49	A2899	\parallel	\parallel	?
0133-2109	1.3305868	-21.083654	131	69	A0177	0	\parallel	\parallel
0145-5012	1.4548714	-50.110378	247	104	A2912	0	\parallel	\parallel
0153-2483	1.5302729	-24.829812	186	87	A2921	0	\parallel	\parallel
0154-2697	1.5492938	-26.963567	135	68	A2924	0	\parallel	\parallel
0156-2609	1.5607925	-26.080661	240	112	A0214	?	\parallel	\parallel
0157-3273	1.5709466	-32.727195	127	61	s0167	0	\parallel	\parallel
0157-2751	1.5755244	-27.507008	170	91	A2928	\searrow	\parallel	\parallel
0168-5458	1.6854490	-54.572596	206	95	A2933	\perp	\parallel	\parallel
0175-5305	1.7507039	-53.046656	131	53	A2941	0	?	\parallel
0179-6283	1.7986149	-62.827489	111	43	s0194	0	\parallel	\searrow
0184-2698	1.8463826	-26.976824	117	41	A2945	0	\parallel	\parallel

Table 4—Continued

PF Number	α [h]	δ [deg]	N_0	N_1	Name	P	δ_D	η
0202-4477	2.0235875	-44.764599	127	66	s0217	0	?	
0206-4119	2.0636706	-41.180976	136	63	A2969	\perp	?	
0207-3573	2.0796464	-35.728896	105	57	A2970	0	?	
0209-2715	2.0957319	-27.140202	129	64	A2972			
0211-2615	2.1148005	-26.147306	112	53	A2973	0	?	
0221-2527	2.2131866	-25.266329	126	60	A0325			
0221-4723	2.2145944	-47.226227	161	79	A2988	0		
0221-3443	2.2183616	-34.422916	103	50	s0233	0	0	
0233-1903	2.3331613	-19.023636	119	61	A3005			
0257-5948	2.5765992	-59.475835	189	100	s0280	0	?	\searrow
0257-3359	2.5785227	-33.585227	113	66	s0278	\perp	\perp	
0258-5925	2.5855871	-59.241983	108	62	s0284	0	0	0
0260-1938	2.6096109	-19.372846	103	47	A0367	\searrow		
0263-5237	2.6360181	-52.368330	123	67	A3038	\perp	\perp	?
0270-2864	2.7005975	-28.638252	166	84	A3041	0		
0273-2634	2.7378078	-26.338302	251	112	A0380			
0275-4645	2.7581401	-46.444123	197	101	A3034	0	0	
0284-7138	2.8401619	-71.376999	143	81	s0303	\perp	0	\perp
0284-4629	2.8422326	-46.289948	137	60	A3059	?	0	
0285-2494	2.8567712	-24.932547	191	98	A0389	0		
0286-2549	2.8684629	-25.483217	262	120	A3062	0		

Table 4—Continued

PF Number	α [h]	δ [deg]	N_0	N_1	Name	P	δ_D	η
0293-2261	2.9300204	-22.600655	188	84	A3069	0	\searrow	\parallel
0296-5278	2.9631675	-52.774388	109	59	A3074	0	\searrow	\parallel
0299-5183	2.9982249	-51.828647	232	103	A3078	\parallel	?	\parallel
0304-7930	3.0468766	-79.293804	115	59	s0322	0	\parallel	\perp
0313-2364	3.1387755	-23.639519	228	118	A0419	\parallel	\searrow	\parallel
0322-3835	3.2280135	-38.341075	106	55	A3098	0	0	?
0325-4274	3.2580363	-42.733818	109	38	A3107	0	\searrow	?
0327-5091	3.2741445	-50.901538	128	66	A3110	0	0	\parallel
0328-4650	3.2881271	-46.494930	181	75	s0335	\searrow	\searrow	\parallel
0329-4427	3.2953835	-44.261528	512	236	A3112	\perp	\searrow	\parallel
0331-5398	3.3183956	-53.979633	154	85	s0339	\perp	\searrow	\parallel
0332-7192	3.3204402	-71.918233	120	71	A3117	0	\parallel	\perp
0334-4314	3.3469023	-43.136727	137	59	s0343	0	\searrow	\parallel
0336-4135	3.3666497	-41.341134	155	82	A3122	0	0	?
0336-4554	3.3681819	-45.536097	106	37	s0345	0	\parallel	\parallel
0347-5571	3.4783319	-55.709845	133	63	A3126	0	\searrow	\searrow
0348-4604	3.4821406	-46.031863	127	49	s0356	0	\perp	\parallel
0350-5258	3.5096315	-52.578089	298	165	A3128	0	\searrow	?
0353-7192	3.5393146	-71.910959	250	126	A3136	?	\parallel	\perp
0360-4072	3.6032229	-40.717086	109	50	A3140	0	\perp	\parallel
0361-3977	3.6157370	-39.769377	157	65	A3142	0	\perp	\parallel

Table 4—Continued

PF Number	α [h]	δ [deg]	N_0	N_1	Name	P	δ_D	η
0364-3272	3.6495967	-32.718875	125	53	A3148	0	\perp	?
0370-5364	3.7097584	-53.639887	320	146	A3158	0	0	\parallel
0376-2427	3.7641976	-24.265911	126	56	A0458	0	\perp	\parallel
0380-4555	3.8023921	-45.541180	115	56	s0393	0	0	0
0380-3349	3.8076228	-33.483048	167	70	A3169	\perp	\perp	\parallel
0381-1789	3.8171204	-17.885726	308	136	A0464	\perp	\perp	\parallel
0383-7395	3.8395870	-73.944664	165	88	A3186	\searrow	\parallel	\perp
0395-6285	3.9539293	-62.849691	103	48	A3191	0	0	0
0396-2698	3.9698326	-26.970222	149	79	A3188	0	\perp	0
0398-3012	3.9822735	-30.113240	157	81	A3194	\searrow	\perp	\parallel
0400-5366	4.0014897	-53.658246	116	56	A3202	\searrow	\searrow	0
0406-1733	4.0672780	-17.326625	125	58	A0473	?	\perp	\parallel
0407-6535	4.0720651	-65.344262	214	100	A3216	\perp	\searrow	\perp
0407-7500	4.0758095	-74.994037	103	50	s0428	0	?	?
0407-4397	4.0798443	-43.966323	105	62	s0416	0	\perp	\parallel
0413-3091	4.1336041	-30.907580	271	131	A3223	0	\perp	0
0418-6383	4.1887482	-63.829294	126	54	A3230	0	\searrow	?
0423-4564	4.2388139	-45.635285	223	106	A3235	\perp	\perp	?
0430-4434	4.3097327	-44.333642	102	49	s0437	\perp	\perp	0
0431-4515	4.3154473	-45.149298	225	90	A3245	\perp	\perp	?
0436-4653	4.3676988	-46.520496	443	200	A3247	\perp	\perp	0

Table 4—Continued

PF Number	α [h]	δ [deg]	N_0	N_1	Name	P	δ_D	η
0437-2443	4.3765635	-24.420645	142	71	A0487	0	\perp	0
0442-3619	4.4243921	-36.181623	116	54	A3253	0	\perp	0
0448-6701	4.4847770	-67.008555	125	70	s0467	0	0	0
0449-5374	4.4945515	-53.737334	212	122	s0463	\perp	\perp	0
0451-4923	4.5144323	-49.229827	120	52	A3264	\parallel	?	0
0451-6138	4.5173059	-61.371014	314	144	A3266	0	\searrow	\perp
0451-4625	4.5187527	-46.243585	286	151	s0468	0	\perp	0
0453-4613	4.5377246	-46.125642	322	163	s0468	0	\perp	0
0454-3268	4.5478622	-32.679840	199	85	A3269	0	\perp	0
0458-3576	4.5827851	-35.756298	266	129	A3277	0	\perp	0
0462-2040	4.6221526	-20.393051	174	74	A0499	0	\perp	0
0465-2208	4.6516903	-22.078465	152	61	A0500	\perp	\perp	0
0471-3288	4.7141684	-32.873363	142	73	s0491	0	\perp	0
0471-4503	4.7151981	-45.026389	531	253	A3284	0	\perp	\searrow
0476-2550	4.7691067	-25.496414	342	167	A0511	0	\perp	0
0480-2050	4.8004748	-20.495970	281	153	A0514	0	\perp	0
0497-3012	4.9703154	-30.119282	110	44	A3297	0	\perp	0
0500-3868	5.0092522	-38.670735	301	148	A3301	\perp	\perp	0
0506-5695	5.0694330	-56.942871	192	80	A3312	0	?	\parallel
0521-4180	5.2189798	-41.790715	212	105	s0515	\searrow	\perp	\searrow
0524-4910	5.2496234	-49.090224	216	103	A3330	\perp	\perp	0

Table 4—Continued

PF Number	α [h]	δ [deg]	N_0	N_1	Name	P	δ_D	η
0542-3150	5.4274828	-31.497747	132	66	A3341	\perp	\perp	?
0542-3070	5.4275138	-30.696179	279	155	A3342	0	\perp	0
0557-2851	5.5729561	-28.507059	135	70	A3354	0	\perp	0
2036-5287	20.3650881	-52.867343	128	60	A3675	\parallel	\parallel	\perp
2053-6310	20.5383289	-63.096072	230	139	A3687	\parallel	\parallel	\perp
2070-3523	20.7036454	-35.229947	110	53	A3705	0	\searrow	0
2077-3251	20.7745307	-32.504550	161	81	A3712	0	0	\searrow
2086-5271	20.8646808	-52.702585	229	148	A3716	0	\parallel	\perp
2092-5487	20.9281238	-54.863643	126	63	A3718	\perp	\parallel	\perp
2098-3648	20.9878184	-36.470935	105	39	A3727	0	?	\searrow
2102-2808	21.0272287	-28.071446	202	111	A3733	\parallel	0	\parallel
2109-3878	21.0992361	-38.778351	191	92	A3740	\parallel	\parallel	\searrow
2112-3960	21.1207422	-39.594784	177	109	s0922	0	\parallel	\searrow
2130-4535	21.3091848	-45.347944	170	83	A3757	0	0	\perp
2143-3473	21.4362913	-34.726841	130	57	A3764	0	?	0
2143-3477	21.4376594	-34.762871	142	62	A3764	0	?	\searrow
2145-4267	21.4512883	-42.662478	105	48	A3767	0	?	0
2149-5088	21.4923816	-50.872873	143	75	A3771	0	\parallel	\perp
2153-4327	21.5352712	-43.268813	159	72	A3775	0	\parallel	\searrow
2154-2275	21.5464792	-22.745785	226	119	A3778	\parallel	?	?
2157-5359	21.5776938	-53.581931	175	109	A3758	0	\parallel	\perp

Table 4—Continued

PF Number	α [h]	δ [deg]	N_0	N_1	Name	P	δ_D	η
2158-6206	21.5821533	-62.055750	233	121	A3782	0	\parallel	\perp
2160-2326	21.6092861	-23.258903	145	72	A2357	\parallel	0	?
2165-5159	21.6564705	-51.588395	378	208	A3976	\parallel	\parallel	\perp
2172-3894	21.7226966	-38.933406	137	66	s0964	?	\parallel	\searrow
2172-1868	21.7243179	-18.677874	101	62	A2365	0	\searrow	?
2175-2414	21.7530741	-24.132785	182	97	A2371	\parallel	?	?
2175-2617	21.7574597	-26.166827	223	115	A3805	\parallel	\parallel	\parallel
2176-5163	21.7635527	-51.622880	123	53	s0968	\parallel	\parallel	\searrow
2177-4386	21.7722038	-43.856255	212	118	A3809	0	\parallel	\searrow
2177-5727	21.7788819	-57.267994	346	187	A3806	0	\parallel	\perp
2179-4598	21.7948239	-45.973743	280	141	s0974	\parallel	\parallel	\searrow
2181-3068	21.8158351	-30.675021	210	116	A3814	0	\parallel	\parallel
2184-5538	21.8460586	-55.374763	139	75	A3816	0	\parallel	\perp
2187-1958	21.8725458	-19.573461	142	79	A2384	0	0	?
2190-5774	21.9037001	-57.738107	698	385	A3822	0	\parallel	\perp
2197-6040	21.9788027	-60.394643	158	82	A3825	0	\parallel	\perp
2201-6666	22.0138069	-66.654358	135	82	s0984	0	?	\perp
2202-6002	22.0276285	-60.018229	231	105	A3827	\parallel	\parallel	\perp
2217-5177	22.1707167	-51.766387	129	71	A3836	0	\parallel	\searrow
2222-3471	22.2295665	-34.706016	101	44	A3844	0	\parallel	?
2223-3675	22.2390700	-36.741350	147	66	s1005	0	\parallel	\parallel

Table 4—Continued

PF Number	α [h]	δ [deg]	N_0	N_1	Name	P	δ_D	η
2225-5153	22.2589927	-51.522674	100	52	A3849	\searrow	\parallel	\searrow
2229-3570	22.2937967	-35.691106	105	53	A3854	?	?	\parallel
2230-3890	22.3097047	-38.892979	125	54	A3856	\parallel	\parallel	\parallel
2233-4598	22.3312483	-45.978565	142	55	A3862	\perp	\parallel	0
2234-5249	22.3418251	-52.489333	216	73	A3864	0	\parallel	0
2241-6428	22.4175145	-64.274067	123	70	s1022	0	\parallel	\perp
2243-4774	22.4361028	-47.732841	121	61	A3876	0	\parallel	\searrow
2243-5723	22.4374814	-57.221621	124	65	A3875	\perp	\parallel	?
2244-8018	22.4465719	-80.176807	159	102	s1014	0	\parallel	\perp
2244-5592	22.4487734	-55.918123	351	152	s1023	\perp	\parallel	\perp
2245-3049	22.4546410	-30.484338	239	121	A3880	0	\parallel	\parallel
2249-4810	22.4930878	-48.098028	157	79	A3883	0	\parallel	\searrow
2251-5468	22.5191493	-54.678874	405	203	A3886	\perp	\parallel	\perp
2256-3778	22.5697146	-37.772273	159	89	A3888	0	\parallel	\parallel
2260-2448	22.6098915	-24.470898	220	115	s1043	\parallel	\parallel	\parallel
2265-3654	22.6511151	-36.538601	368	168	A3895	0	\parallel	\parallel
2277-5266	22.7728262	-52.659033	254	109	A3911	\searrow	\parallel	\searrow
2279-7177	22.7951191	-71.761058	142	70	A3916	\parallel	\parallel	\perp
2282-6440	22.8261247	-64.392424	143	72	A3921	0	\parallel	\perp
2284-4641	22.8467747	-46.406595	390	188	s1066	0	\parallel	\parallel
2286-3346	22.8653802	-33.457812	108	41	A3926	0	\parallel	\parallel

Table 4—Continued

PF Number	α [h]	δ [deg]	N_0	N_1	Name	P	δ_D	η
2290-5820	22.9037119	-58.196725	124	69	A3939	0		\searrow
2292-5564	22.9209509	-55.634206	146	69	A3938	0		0
2297-3077	22.9794554	-30.769579	133	68	s1075	0		
2299-5613	22.9932807	-56.122212	128	55	A3950	?		\searrow
2310-4524	23.1013885	-45.234819	126	54	A3970			
2314-1991	23.1444582	-19.901091	154	79	A2538	?		
2317-2446	23.1707661	-24.452256	127	65	A2542	?		
2317-2276	23.1767610	-22.754556	166	65	A2546	0		
2318-2054	23.1897451	-20.532686	140	66	A2548	0		
2319-2888	23.1935895	-28.876656	227	119	A3978	0		
2320-2162	23.2017030	-21.613963	231	116	A2554	0		
2320-7329	23.2070355	-73.283348	121	39	s1097	\perp		\perp
2323-4265	23.2334892	-42.648829	135	63	s1101	0		
2325-3781	23.2561310	-37.809397	129	58	A3984			
2328-7492	23.2873598	-74.915989	181	60	s1105	0		\perp
2331-4225	23.3110602	-42.249813	343	163	s1111	0		
2334-7330	23.3424547	-73.295282	146	57	A3992			\perp
2335-2314	23.3528905	-23.131756	232	117	A2580	0		
2335-4186	23.3583306	-41.854040	124	62	A3998	0		
2337-2046	23.3767020	-20.457046	138	73	A2583	0		
2338-5170	23.3838174	-51.697333	139	61	A3999	0		

Table 4—Continued

PF Number	α [h]	δ [deg]	N_0	N_1	Name	P	δ_D	η
2346-6242	23.4609620	-62.415941	109	37	A4006	\perp	\parallel	?
2350-3920	23.5033142	-39.196389	123	67	A4008	?	\parallel	\parallel
2359-5228	23.5921173	-52.279494	124	56	A4018	0	\parallel	\parallel
2375-2604	23.7545938	-26.033124	122	68	A2660	\searrow	\parallel	\parallel
2387-3433	23.8753332	-34.322018	232	134	s1157	0	\parallel	\parallel
2391-2767	23.9149501	-27.661862	113	58	A4053	0	\parallel	\parallel
2391-2044	23.9196846	-20.430089	151	69	A2679	0	\parallel	\parallel
2393-2108	23.9385755	-21.070632	101	49	A2680	?	\parallel	\parallel
0320-2704	3.2014478	-27.032059	320	150	A3094	0	?	\parallel
0383-1801	3.8305438	-18.009478	366	172	A3175	\perp	\perp	\parallel
0468-4526	4.6835843	-45.252794	277	126	s0486	0	\perp	\searrow
2020-5671	20.2003641	-56.706966	147	73	s0854	0	\parallel	\perp
2095-4683	20.9545182	-46.826834	343	132	A3720	0	\parallel	\perp
2265-1738	22.6542356	-17.370522	126	54	A3897	0	\parallel	\parallel
2308-4429	23.0869996	-44.289679	290	133	A3969	\parallel	\parallel	\parallel
2332-7391	23.3291361	-73.904396	167	52	s1104	0	\parallel	\perp
2378-2816	23.7840810	-28.151115	330	169	A4037	0	\parallel	\perp

